

AG Optical Systems



Imaging Dall Kirkham Astrograph Manual

Version 10 2014

Please read through the entire manual before making any adjustments to your AG Optical Systems telescope.

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Introduction

Thank you for your purchase of an AG Optical Systems Imaging Dall Kirkham Astrograph. Your telescope has been carefully crafted using modern manufacturing technologies and high-tech materials to provide outstanding, reliable performance. As with any high quality optical instrument, care must be taken in the use and maintenance of the telescope to ensure it performs to its maximum potential. Should you have any questions that are not addressed by the contents of this manual please contact AG Optical Systems.

System Specifications

System Focal Ratio: 6.7 (nominal)

Primary Mirror Substrate: Schott Borofloat

Primary Mirror Coating: Enhanced aluminum

Secondary Mirror Substrate: Schott Borofloat

Secondary Mirror Coating: Enhanced aluminum

Back focus: nominally 11.2 inches from back plate surface to focal plane

Cooling fans: 12 VDC, center pin positive, 5.5 x 2.1 mm

Receiving the Telescope

Please inspect the shipping box for any damage when you receive the telescope from the shipper. If any significant damage to the box is visible (crushed corners, major tears in the cardboard, water damage, etc.) you may want to bring it to the attention of the delivery person and document the damage by taking images of it.

Once you have the box opened, carefully inspect the telescope for any damage and, if any should be found, document the damage with a photograph and immediately contact the shipping company and AG Optical Systems.

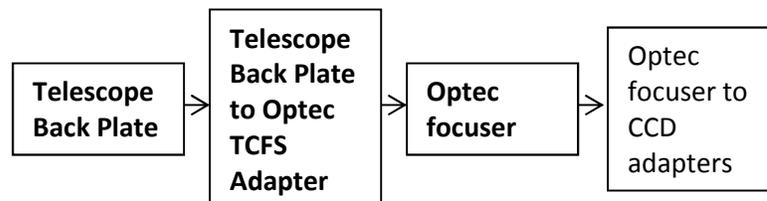
Initial Assembly

Very little assembly is required to prepare your AG Optical Systems astrograph for use.

Optec Focuser (standard)

You will need to attach the Optec TCF-S3i focuser to the back plate of the iDK telescope. To do this, slide the focuser over the focuser adapter (already mounted to the back plate) and tighten the set screws at the base of the Optec focuser to secure the focuser in place. Take care to ensure the focuser is square to the back plate and securely mounted.

Optec Configuration



Items in **bold** type are supplied by AG Optical Systems with the Optec focuser option. The user will need to acquire the adapters required to mount their particular CCD camera to the Optec focuser. Please contact AG Optical Systems to discuss your specific requirements as AG Optical Systems can provide almost any adapter you require.

With the Optec focuser in place, approximately 5” of back focus is available. This distance may vary a small amount due to variance in the optical manufacturing process.

Collimation

Precise collimation is critical to ensure the full potential of your AGO astrograph is realized. Best results will be achieved when you use quality collimation tools and follow a systematic approach. Be patient and do not settle for anything less than “textbook” perfect collimation. AG Optical Systems suggests you read many of the excellent online resources describing how to collimate a Cassegrain or Ritchey Chretien telescope. These resources provide a rich wealth of detailed theoretical and practical information that will enable you to achieve precise collimation of your AGO iDK astrograph.

Although AG Optical Systems collimates each iDK astrograph prior to shipment, some fine tuning of the collimation may be required if the scope was not carefully handled by the shipping company. To facilitate the collimation process, AG Optical Systems suggests you have the following collimation tools on-hand:

Useful Collimation Tools

- 2” laser collimator
- 2” Cheshire sight tube
- Takahashi Collimating Telescope
- Focuser adapters to allow the use of 2” collimation tools

Collimation Process Overview

Below is a general overview of the collimation process. Detailed instructions follow in the subsequent section. **Please read the entire manual before attempting to adjust your telescope.** Always exercise caution when using a laser collimator. Keep in mind that collimation is often an iterative process so that changes in the tilt of the focuser or collimation of the secondary or collimation of the primary often require you to recollimate other elements of the system.

1. Place the telescope on a flat, stable surface.
2. Insert the proper combination of adapters into the focuser to place the collimation tools near the focal plane of the system. Make sure the adapters are properly tightened and seated to ensure no tilt is introduced into the system.
3. Insert a quality 2” laser collimator ensuring that it is firmly seated against the face of the focuser. Turn on the laser and observe where the laser spot falls on the face of the secondary mirror. If the laser spot falls off to the side of the center spot, double check to make sure the laser is squarely seated in the adapter. Also, double check your laser collimator to ensure that the laser beam axis and mechanical axis are coincident. You can check this by loosening the adapter and rotating the collimator (while making sure the laser collimator is firmly seated

against the adapter). If the laser spot traces an arc it means that the laser collimator is not properly aligned. In this case, the laser collimator should be replaced.

4. Once you are sure your laser collimator is properly aligned observe where the laser spot falls on the secondary mirror. If it falls on the secondary center spot no adjustment is required. If it falls off to one side of the secondary center spot, collimate the secondary mirror using the Tak Collimation Scope and recheck the centration of the secondary mirror. If necessary, adjust the centration of the secondary mirror via the spider arm truss connector screws.
5. Use a Takahashi Collimating Telescope to collimate the secondary mirror.
6. On a clear night, aim the telescope at a star and defocus the star until the shadow of the secondary mirror is clearly visible. Make fine adjustments to the secondary mirror until the shadow of the secondary mirror is concentric with the diffraction rings. If the rings of the out of focus diffraction pattern are brighter on one side of the diffraction pattern than on the other side of the diffraction pattern and adjustments to the secondary mirror do not correct this, you will need to collimate the primary as described in the next step.
7. Place your CCD camera on the telescope and take an image (focused). Inspect the stars across the field of view. If the stars are not round in any corner(s), make a small collimation adjustment to the primary mirror and take another image to assess the impact of the change. Takes notes to keep track of the changes you make and results you get.

Detailed Collimation Process

Collimating an AG Optical Systems Imaging Dall Kirkham is accomplished by making adjustments to the primary mirror cell and secondary mirror cell until the optical axis of both mirrors are coincident and co-axial with the mechanical axis of the focuser.

The key to successfully collimating your iDK astrograph is to use a systematic approach that involves making small adjustments to each mirror, assessing the results of the move, and then making subsequent adjustments to further refine the collimation of the astrograph. Once collimation is achieved, the system will hold collimation for long periods of time unless the OTA is subject to rough handling.

AG Optical Systems carefully aligns the secondary mirror on our test bench using a 2" laser collimator, a Takahashi Collimating Telescope, and an artificial star. After shipping, however, the collimation of the system should be checked and, if necessary, adjusted.

Adjusting the Secondary Mirror

The collimation of the secondary mirror is adjusted using two, spring-loaded collimation screws located on the face of the secondary hub. The black socket cap screw should not be adjusted. Again, the black screw should not be adjusted; only adjust the two silver 1/4" socket cap screws to make collimation adjustments to the secondary mirror. Ensure that all three lock screws are loosened prior to making any adjustments. Once collimation is achieved, the position of the secondary mirror can be locked into place using lock screws. Do not over-tighten the lock screws... gently snug is good

enough! (NOTE: newer iDK astrographs have a single lock screw per collimation adjustment screw rather than a pairs of lock screws as pictured below).

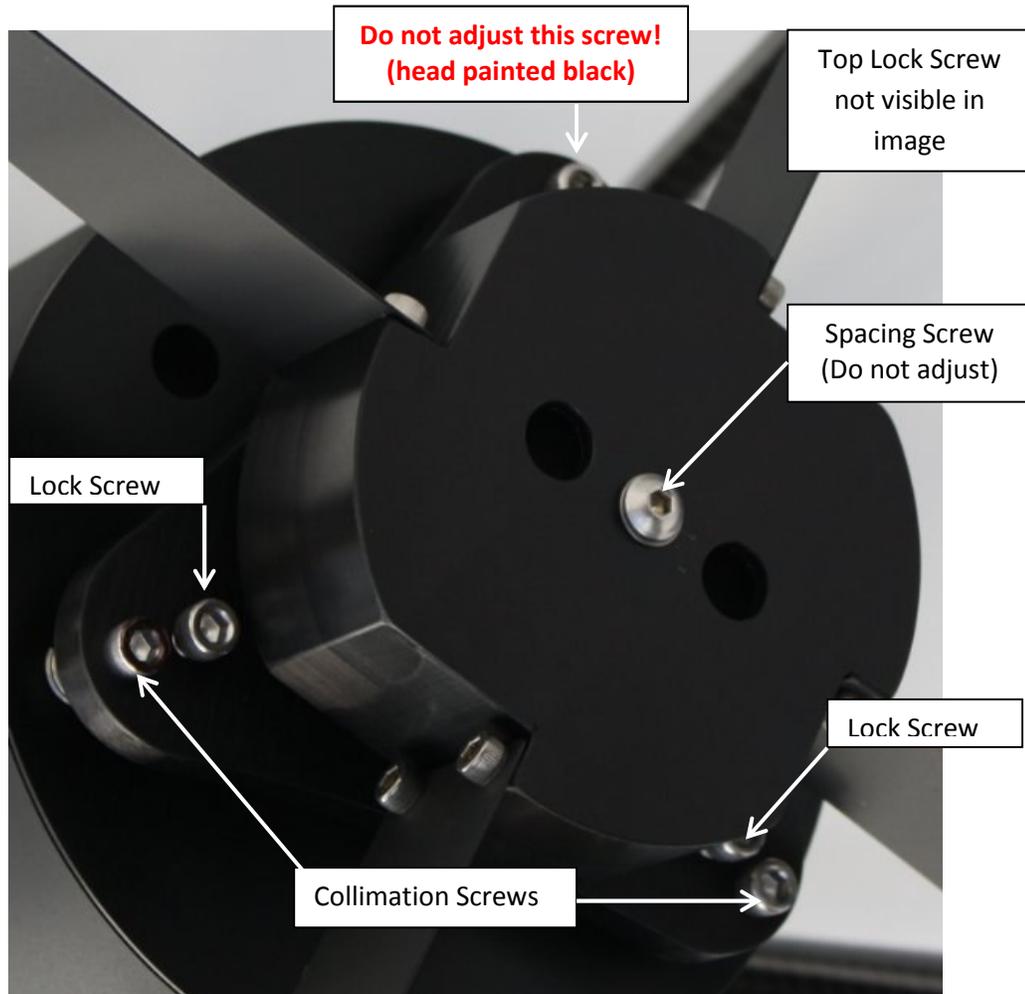


Figure 1 iDK Secondary Hub with Collimation Screws

Initial Adjustment of the Secondary Mirror

The center of the secondary mirror has been marked with a dot. This dot can be used with a Takahashi Collimating Telescope to collimate the secondary mirror. Detailed instructions are provided with the Tak Collimating Telescope but an overview of the process is provided below.

- 1) Insert the Tak Collimating Scope into your 2" focuser adapter
- 2) Slide the focus adjustment of the Tak Collimating Scope until the view of the secondary spot comes into focus. Please note that the secondary center spot will appear larger through the Tak Collimating scope than it does to your naked eye. If the secondary center spot is not visible, you may need to make some random adjustments to the secondary mirror to bring the secondary center spot into view.
- 3) Once the secondary spot is visible and is focused, carefully adjust the two collimation adjustment screws on the secondary assembly to perfectly center the image of the secondary center spot in the silver/gray annulus at the center of the field of view. This is a reflection of the polished surface of the Tak Collimating Scope.
- 4) Once the image of the secondary center spot is perfectly centered on the silver/gray annulus of the Tak Collimating Scope, the secondary is well collimated and may only require a slight tweak using a defocus star.

Please note that the instruction provided with the Takahashi Collimating Telescope for collimating a Cassegrain-type telescope or Ritchey Chretien telescope will work just as well for the iDK telescope.

Checking Secondary Mirror Centration

Insert your laser collimator into the focuser ensuring that it is firmly and squarely seated against the adapter. Turn on the laser and observe where the center laser spot falls on the secondary mirror. If it falls on the secondary mirror center spot no adjustment to the focuser is required. If it falls off to the side of the secondary center spot, collimate the secondary mirror and then adjust the centration of the secondary mirror using the four screws located at the outside ends of the spider arms (one screw per arm). Loosen and tighten opposite pairs of screws to move the secondary mirror. Iteratively collimate the secondary mirror and then check centration as collimating the secondary will slightly affect the centration of the secondary mirror.

Checking/Adjusting Primary Mirror Collimation

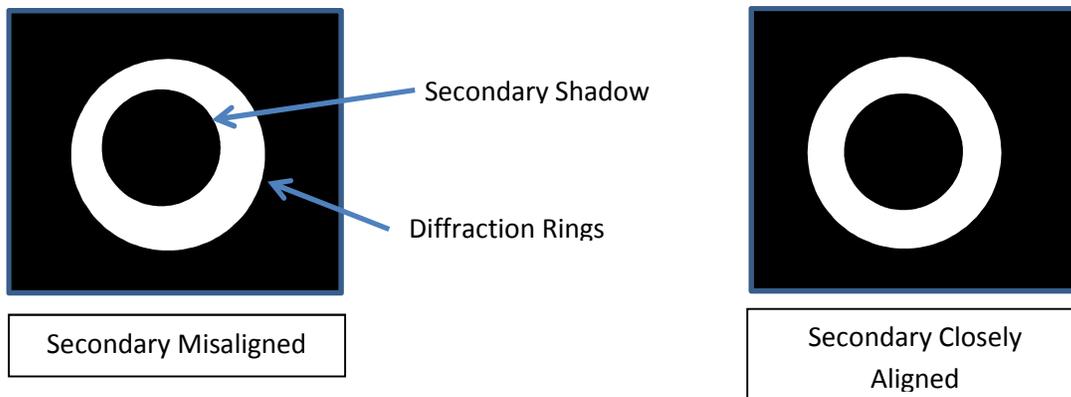
AG Optical Systems collimates the primary mirror of each iDK on our test bench prior to shipment. After receiving the scope, it may be necessary, however, to tweak the alignment of the primary if astrograph was jarred during shipping. Before adjusting the primary mirror, however, ensure that the focuser has no tilt and the secondary is properly collimated.

The primary mirror cell collimation adjustments are identical to the collimation adjustments on the secondary mirror cell. Two collimation screws are used to adjust the cell while one screw (which you should not adjust) serves as a pivot point. The black socket cap collimation screw serves as a pivot point.... DO NOT ADJUST IT. Only adjust the two silver collimation screws to collimate the primary mirror. Lock screws are used to secure the mirror cell in place once collimation has been

achieved. (NOTE: newer iDK astrographs have a single lock screw per collimation adjustment screw).

Refining Collimation

On a clear night with steady seeing point your iDK astrograph at a relatively bright star and insert an eyepiece that gives you 150x to 200x magnification. Defocus the image of the star until the secondary shadow and diffraction pattern is clearly visible. Ensure that the image of the star is centered in the field of view. If the shadow of the secondary mirror is not centered in the diffraction image of the star (see below) make a small adjustment to one of the secondary collimation screws, re-center the image of the defocused star in the field of view, and note how the image changed. Assuming the shadow of the secondary mirror is still not centered, make a small adjustment to the second collimation screw, re-center the image of the defocused star in the field of view, and note how the image changed. Continue making adjustments to the secondary collimation screws until the shadow of the secondary mirror is precisely centered in the diffraction image of the star. It may take some practice to get good at this process as some judgment is required to determine when the shadow is exactly centered.



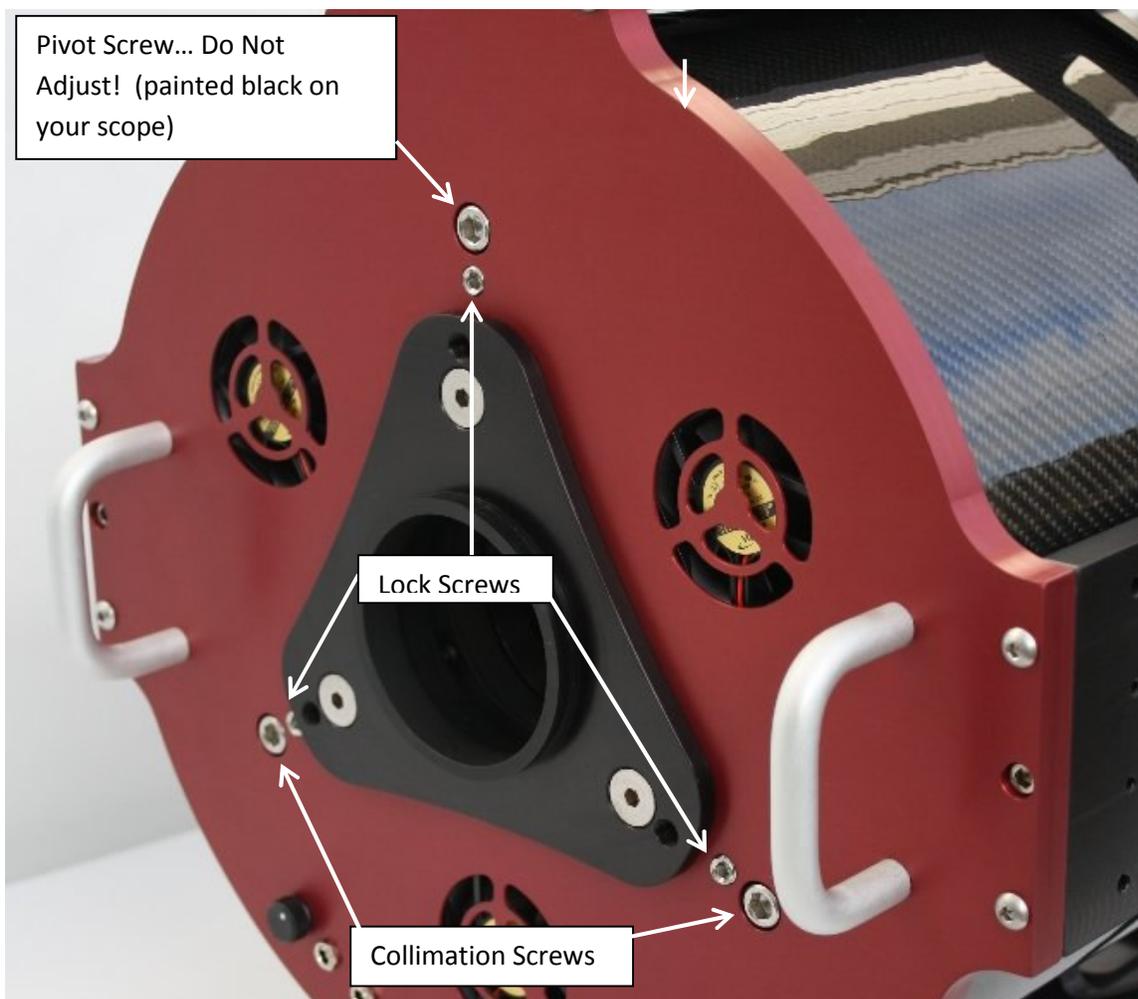
Once the secondary mirror has been aligned, carefully tighten the lock screws in a sequential order. AG Optical Systems recommends that you tighten one lock screw until you feel it just touch the secondary cell, repeat for the second lock screw, repeat for the third lock screw, and so on. Then, after all lock screws have been adjusted, gently snug up the first lock screw followed by the second lock screw and so on following the same pattern you used when initially tightening the lock screws. Please note that the lock screws do not need to be very firmly tightened in order to secure the secondary cell in place. Recheck the collimation of the secondary and adjust if necessary.

If the rings on one side of the diffraction pattern are brighter than on the other side of the diffraction pattern and you are unable to eliminate this by adjusting the secondary mirror, the primary mirror is likely out of collimation and will need to be adjusted.

Note: To remove the secondary mirror cell from the spider completely back out the secondary collimation screws and the pivot screw. Removing the secondary mirror cell will release several spring washers. Do not lose these springs and be sure to replace them in their proper positions otherwise the secondary mirror cell will not function properly. Contact AG Optical Systems before removing the secondary mirror if you have any questions.

The most precise way to align the primary mirror is to take images of actual star fields through the scope to assess the overall collimation of the system. Ensure that the focuser has no tilt and the secondary is properly collimated.

The primary mirror cell collimation adjustments are identical to the collimation adjustments on the secondary mirror cell. Two collimation screws are used to adjust the cell while one screw (which you should not adjust) serves as a pivot point. The black socket cap collimation screw serves as the pivot point.... DO NOT ADJUST IT. Only adjust the two silver collimation screws to collimate the primary mirror. Lock screws are used to secure the mirror cell in place once collimation has been achieved. (NOTE: newer iDK astrographs have a single lock screw per collimation adjustment screw rather than a pairs of lock screws as pictured below).



The collimation of the primary mirror is adjusted using two, spring loaded collimation screws located on the face of the telescope back plate at roughly the 4 and 8 o'clock positions. The black recessed socket cap screw that is visible at the top (12 o'clock position) of the back plate should not be adjusted. Once collimation is achieved, the position of the primary mirror can be locked into place

using lock screws. (NOTE: newer iDK astrographs have a single lock screw per collimation adjustment screw).

Point your iDK astrograph at a star-rich portion of the sky at an elevation greater than 45 degrees above the horizon. Carefully focus the astrograph and take a short exposure (around 3 to 5 seconds). It is very helpful if your mount is well-aligned as tracking errors can make it more difficult to see collimation errors. View the shapes of the stars across the field of view. If the stars are round across the field of view, the primary is well-collimated and the scope is ready for use. If the stars are oblong in one or more corners, it is necessary to adjust the collimation of the primary mirror.

Ensure that all of the lock screws are loose. Make a slight adjustment to one of the primary mirror cell collimation screws (not the black screw), take an image, and assess how the star shapes changed. If the star shapes improve but are still not perfect, make a slight adjustment to the second primary mirror cell collimation screw, take an image, and assess the change. Continue this “adjust and assess” process until all of the stars across the field of view are round. Be patient as this process may require several iterations.

Once the primary mirror has been aligned, carefully tighten the lock screws in a sequential order. AG Optical Systems recommends that you tighten one lock screw until you feel it just touch the primary cell, repeat for the second lock screw, repeat for the third lock screw, and so on. Then, after all lock screws have been adjusted, gently snug up the first lock screw followed by the second lock screw and so on following the same pattern you used when initially tightening the lock screws. Please note that the lock screws do not need to be very firmly tightened in order to secure the primary cell in place. Recheck the collimation of the primary mirror and secondary mirror and repeat the collimation process if necessary.

Note: Do not completely back out the primary mirror cell collimation screws and the pivot screw as this will cause the primary mirror cell to come free. This could result in serious damage to your iDK astrograph.

Tips

- Use a good quality laser collimator that projects a point to confirm that the focuser is pointing at the center of the secondary mirror.. Confirm that the laser is properly aligned.
- Use a Takahashi Collimating Scope as a very convenient way to obtain good collimation of the secondary mirror.
- Be sure to recheck the collimation of the secondary after making adjustments to the primary mirror. Collimation is an iterative process.
- Ensure that the scope has had sufficient time to cool prior to attempting to precisely collimate the scope.
- Focus carefully as even a slight amount of defocus can make it difficult to collimate the primary mirror using your CCD camera.
- Leave the cooling fans constantly running at a medium to slow speed as this will help keep the telescope thermally equalized as well as help prevent dew from appearing on the secondary mirror.
- Don't give up until you achieve text book collimation. Do not over-tighten collimation lock screws.... snug is good enough!

Care and Cleaning

Warm water or gentle household cleaners (such as Windex) may be used to clean the exterior of your AGO astrograph. Paint thinners and other strong chemical solvents should not be used as they may cause damage to the finish of your astrograph.

WARNING

AGO recommends that you **always** keep your AGO astrograph covered when the telescope is exposed to direct sunlight. The black finish (paint or clear coated carbon fiber) rapidly absorbs heat which, in extreme cases, could cause damage to the paint and in any case causes undesirable heating of the telescope.

Cooling Fan Operation

Your AG Optical Systems astrograph is equipped with three fans to decrease the time it takes the primary mirror to achieve thermal equilibrium with ambient air. These fans require 12 volt DC power that is supplied via the center pin positive 5.5 mm x 2.1 mm female connector located on the back plate of the telescope.

The speed of the fans can be adjusted using the small black knob located on the back plate. AG Optical Systems recommends that you ramp the fans to their highest speed and then slow them to the speed you desire. Only a slight turn on the knob is required to adjust the speed of the fans.

AG Optical Systems Thermal Control System (option)

Introduction

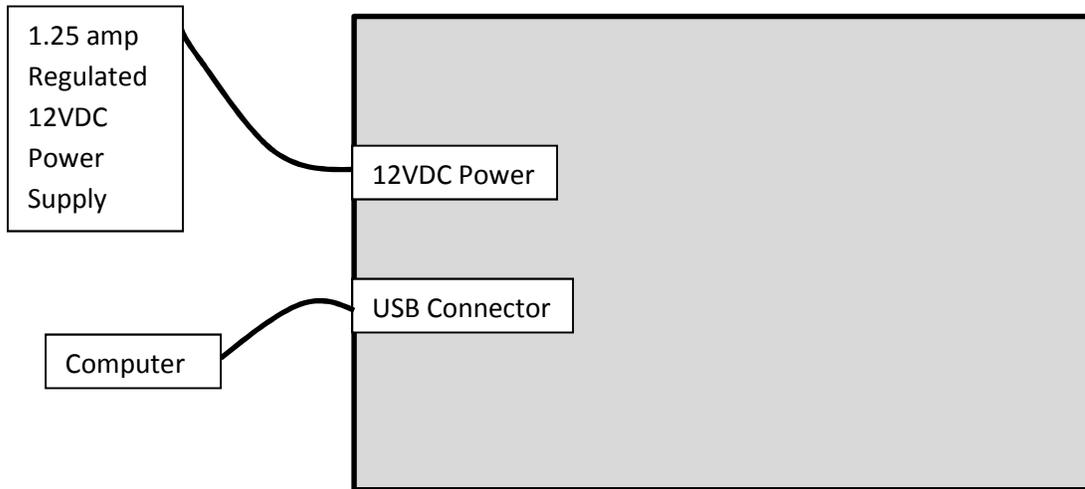
The AG Optical Systems Thermal Control System (TCS) consists of:

- TCS Control Box
- AGO Thermal Manager software application (Windows compatible)
- Primary mirror cooling fans
- Primary mirror heater
- Secondary mirror heater
- Primary mirror temperature sensor
- Secondary mirror temperature sensor
- Ambient temperature sensor
- cabling

The system is designed to maintain the temperature of the primary and secondary mirrors within a few degrees of ambient air temperature by automatically turning on and off the heating and cooling elements of the TCS according to a set of parameters set by the user. Given the wide variability of factors affecting the thermal behavior of the telescope system, AG Optical System designed the TCS to be a simple but effective system that the user can easily monitor and adjust to achieve the best possible performance for their specific telescope system.

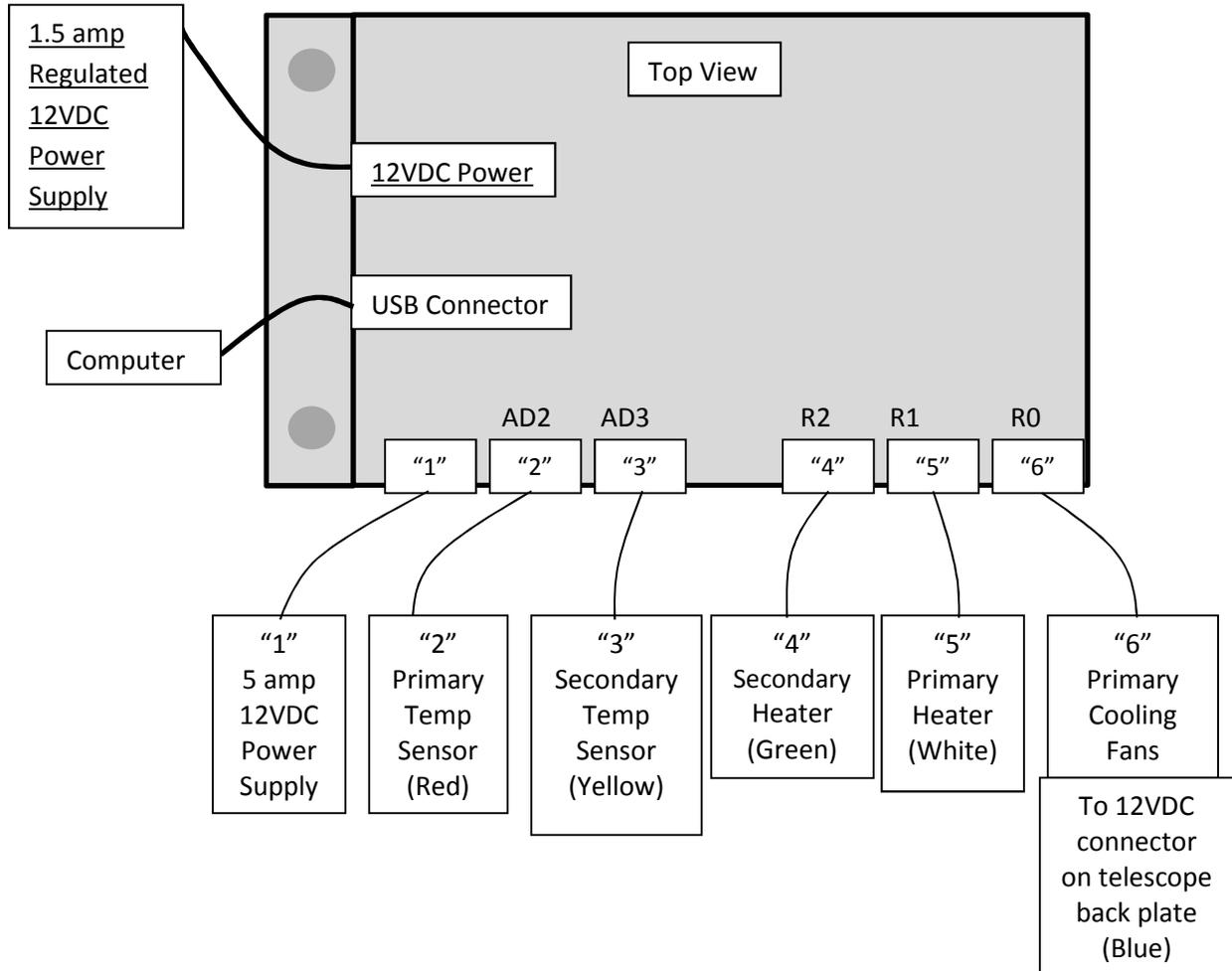
Software Installation

The TCS software installation file is located at the AG Optical Systems website under the “Support” tab. Please download the file to a location on your computer. **BEFORE** installing the software, connect the TCS Control Box to the computer using the supplied USB cable AND power cable. Be sure to power the Thermal Control Box using a high quality, regulated 12vdc power supply with at least 1.25 amps capacity. The USB connector and 12 VDC power port are located on the back plate side of the TCS Control Box.



Wiring Diagram

Below is the wiring diagram describing how the various thermal control system elements are connected. A simple numbering and color scheme (1 through 6) is used to ensure each element is properly connected to the TCS Control Box.....Yellow connects to Yellow, Blue to Blue, etc. Some of the connection points are located on the telescope back plate.



17" and larger iDK models have four cooling fans installed on the carbon fiber mirror shroud. These fans greatly reduce internal air currents by scrubbing the boundary layer of warm air on the face of the primary mirror. The 12vDC center pin positive power connector and speed control knob for the shroud fans is located on the back plate and is identified by the letters "Sh".

The other power connectors on the back plate are for the primary cooling fans and TCS temperature control elements (if applicable).

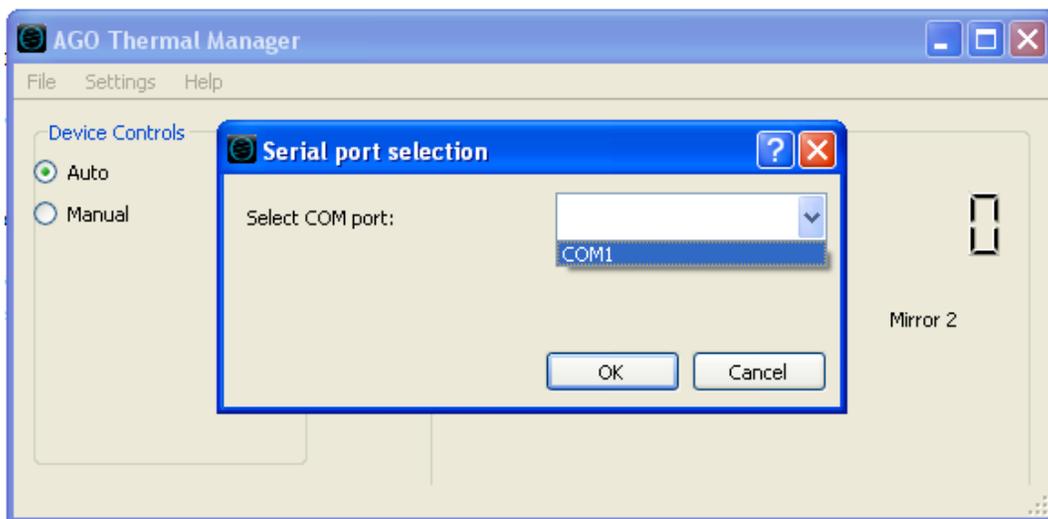
Note: It is suggested that you use two separate power supplies for the TCS Control Box. A quality, 12VDC regulated power supply capable of supplying at least 1.25 amps should be used for the power source for the TCS Control Box (underlined in the diagram above). A separate 12VDC power supply capable of supplying at least 2.5 amps should be used to power the cooling fans and heaters. Damage to the control board may occur if a non-regulated or non-switched power supply is used.

Operation

Once you have connected the TCS to the computer and powered it on, “double click” on the TCS installation file to begin the installation process. Please wait while the installer loads the application to your computer and click “Finish” to complete the installation process. The TCS application is now ready to use.

Navigate to “Start” -> “All Programs” -> “AG Optical” -> “Thermal Manager” and click on “Thermal Manager” to open the TCS application.

Once the application opens, you may need to select the COM port your computer has assigned to the TCS Control Box. To do this, in the AGO Thermal Manager application click on the “Settings” menu and select “Serial port settings...”. Choose a COM port from the drop down menu and click “OK”. If you still receive a “Communications timed out!” error, repeat the process and select a different COM port.



Once you have selected the correct COM port, the TCS application will begin reading temperature data.

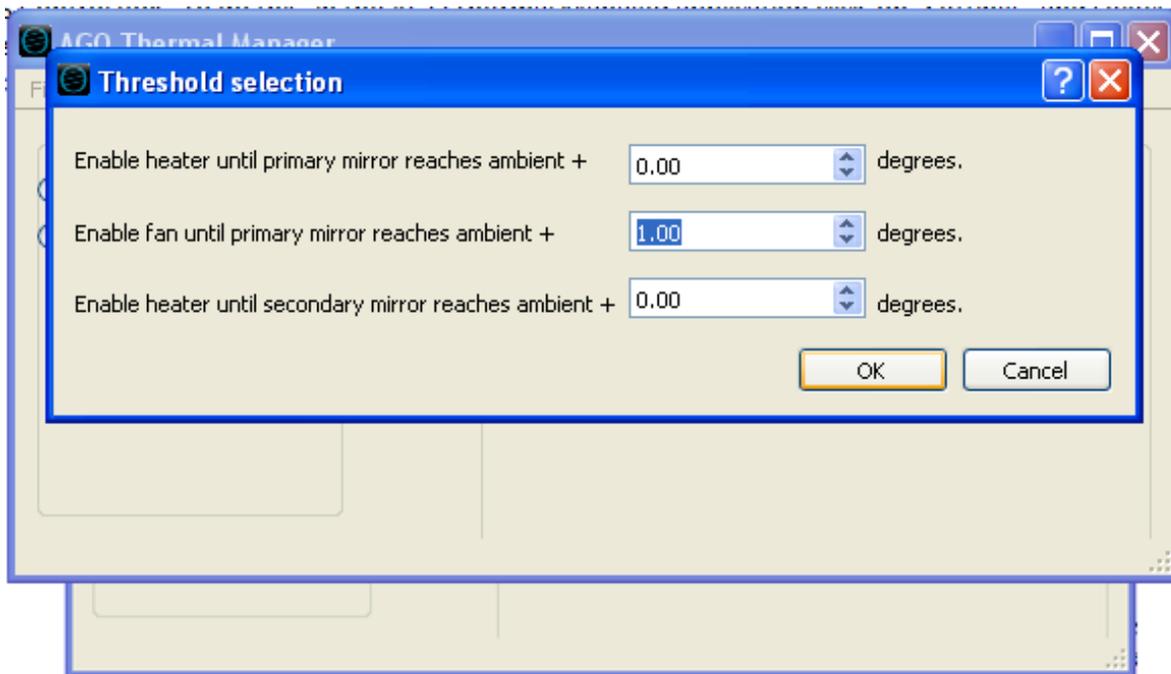
When the TCS application is in “Auto” mode (the “Auto” radio button is selected) “Threshold settings” activate the cooling fans and heaters according to a set of simple rules:

- The system will activate the primary mirror cooling fans if the primary mirror temperature is warmer than ambient temperature by a user-defined amount.
- The system will activate the primary mirror heater if the primary mirror temperature is cooler than ambient temperature by a user-defined amount.
- The system will activate the secondary mirror heater if the secondary mirror temperature is cooler than ambient temperature by a user-defined amount.
- The system will not allow the primary mirror heater and cooling fans to be simultaneously active.

Activation Threshold Settings

The parameters controlling when the heating and cooling elements are active are defined in the “Settings” -> ”Threshold settings” dialog. Every telescope operates in a unique environment so some tuning of the parameters may be necessary to maximize the performance of the TCS. To adjust the threshold settings, use the up/down selection buttons to raise or lower the threshold for each of the three threshold options. The cooling fan setting must always be at least 1 degree higher than the primary heater setting. This prevents the cooling fans and primary heater from running at the same time. It also prevents rapid switching between the primary heater and the cooling fans.

Primary Heater Threshold: The first setting defines when the primary heater is active. Enter a number (generally, 0 (zero) is a good selection) to define when the system will activate the primary heater. If, for example, you enter “1”, the system will power the primary heater until the temperature reported by the primary temperature sensor is one degree above ambient temperature. Typically, a setting of “0” is adequate to prevent dew from forming on the primary mirror. You may need to adjust this setting, however, based on your local conditions.



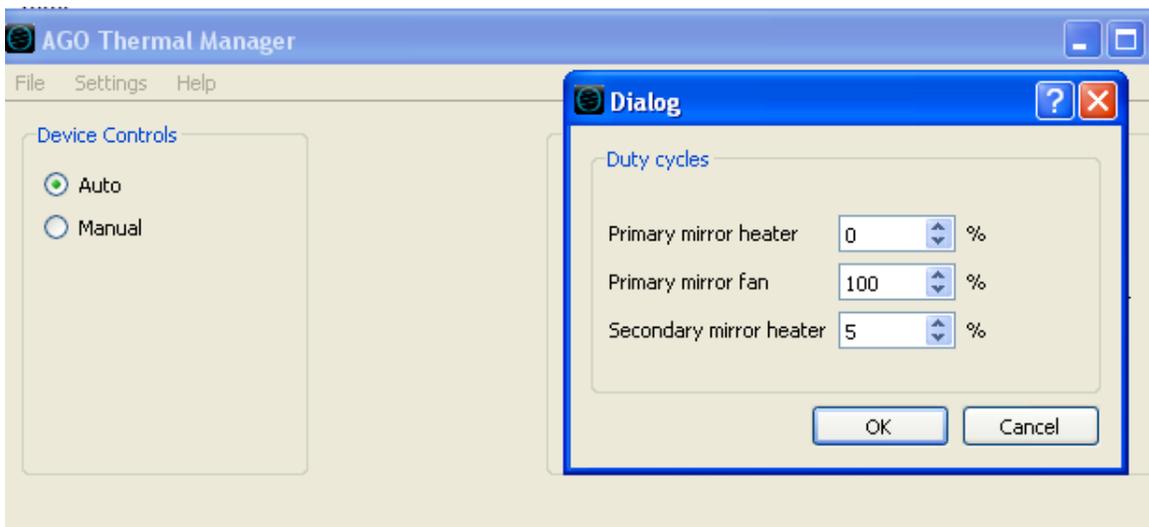
Primary Mirror Cooling Threshold: The second setting defines when the primary cooling fans will activate. Any time the primary mirror is warmer than ambient by the threshold amount, the cooling fans will activate. In general, the cooling fans will be active a large proportion of the time the telescope is in use as the primary mirror’s temperature will lag ambient temperature as the temperature drops over the course of the evening. A setting of “1” is a good place to start. You may need to adjust this setting, however, based on your local conditions. Please note that the cooling fan threshold must always be at least 1 degree greater than the primary mirror heater threshold setting. This prevents the cooling fans and primary heater from running at the same time. It also prevents rapid switching between the primary heater and the cooling fans.

Secondary Heater Threshold: The logic and process for setting the secondary heater threshold is the same as that for the primary heater threshold setting. Typically, a setting of “0” is adequate to prevent dew from forming on the secondary mirror. You may need to adjust this setting, however, based on your local conditions.

Duty Cycle Settings

Duty cycle settings define the amount of time per unit time the primary heater, secondary heater, and cooling fans are active when the temperatures of the primary and/or secondary mirror are outside the limits defined in the threshold settings.

For example, if the secondary mirror heater is active because the secondary mirror is too cool, a duty cycle setting of 5% for the secondary heater will cause the secondary heater to be active 3 seconds out of every 60 seconds. If the duty cycle is set to 50%, the secondary heater will be active 30 seconds out of every 60 seconds.



The duty cycle settings provide the user with a means to fine tune the amount of heat that is applied to an optic. If not enough heat is applied (rarely a problem) the mirror may not heat fast enough to prevent dew. If too much heat is applied too quickly, the mirror will distort and image quality will suffer.

AG Optical recommends the following duty cycle settings as a starting point:

Primary mirror heater: 0%
Primary mirror fan: 100%
Secondary mirror heater: 5%

The primary mirror very rarely forms dew so AG Optical Systems strongly suggests that you disable the heater while the telescope is imaging by setting the primary mirror heater duty cycle to 0%. This will prevent any distortion of the primary mirror that can occur when heat is applied to the mirror.

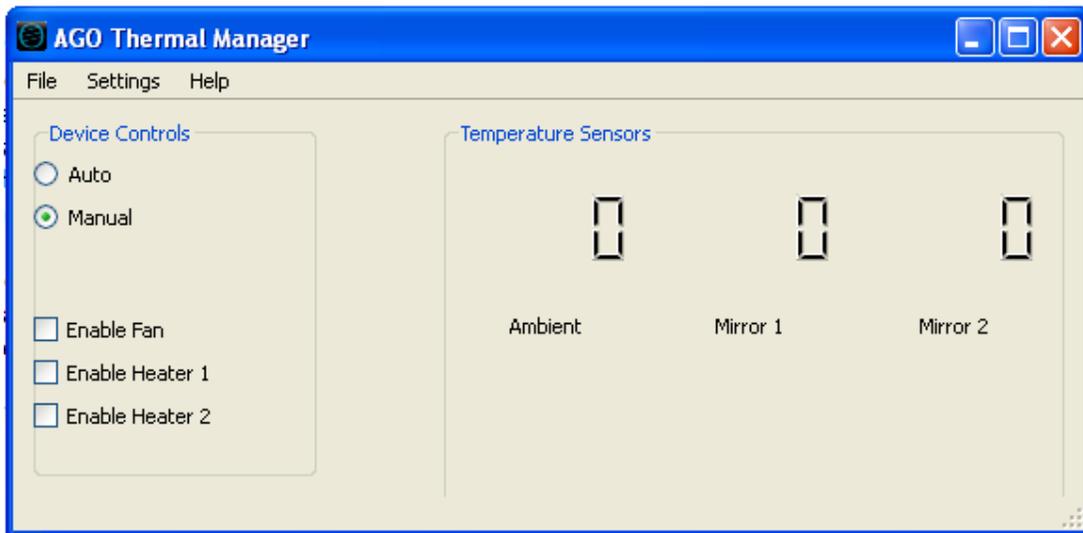
The most likely time for the primary mirror to form dew is in the dawn hours when ambient air temperature begins to increase (rather than fall as it typically does during the evening and early morning hours). As the air temperature begins to increase, a point will be reached at which the temperature of the primary mirror is less than that of ambient air thereby making the primary mirror susceptible to dew formation. You can help prevent dew from forming on the primary mirror by setting the duty cycle of the primary heater to 75% or greater after the telescope has completed its imaging run for the evening. The heat applied to the primary will help prevent dew from forming in the morning hours when primary dew formation is most likely. However, AG Optical Systems recommends that the primary heater duty cycle be set to 0% when the scope is imaging.

The secondary mirror has much less mass than the primary mirror and therefore cools much more rapidly. It is susceptible to dew formation much more quickly than the primary mirror. A duty cycle setting of 5% applies a modest amount of heat to the secondary mirror in small amounts. A low duty cycle helps keep the secondary mirror dew free while minimizing the optical distortion that can occur when too much heat is applied too quickly to the mirror. With the secondary mirror duty cycle, it is advisable to start with a low duty cycle setting and only adjust it upwards if the secondary forms dew.

The cooling fans should have a duty cycle of 100% to cool the primary mirror as quickly as possible. The cooling fans also help mix air in the tube to mitigate tube currents which are detrimental to high-resolution imaging.

Manual Mode

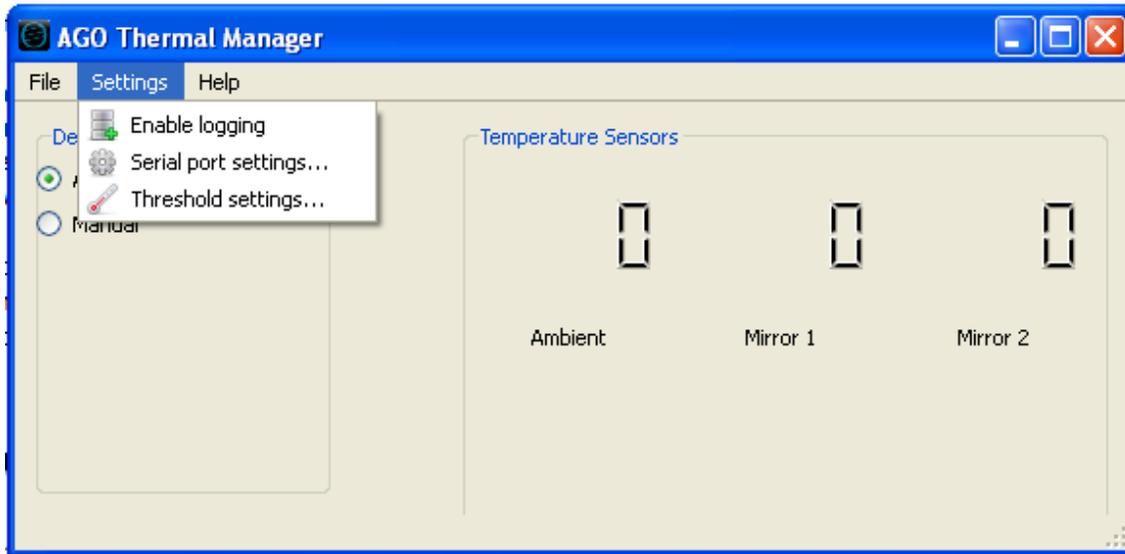
The AGO Thermal Manager can be set to “Manual” mode by selecting the “Manual” radio button.



While in “Manual” mode, you can manually turn on the cooling fans and heaters by selecting the appropriate box. Manual mode may be useful when you are attempting to clear dew that has formed on a mirror.

Logging Data

Selecting the “Enable logging...” capability under the “Settings” menu will generate an Excel CSV file that contains temperature readings, state conditions for the heating and cooling systems, and an associated time stamp for each reading. This data can be used to analyze the cooling and heating characteristics of your telescope system and may be useful in helping you determine the optimal threshold settings for your particular observing environment. To save the data file, select the “Save log...” option under the “File” menu and save the file to a location on your computer.



Shroud (option)

The AG Optical Systems iDK shroud is hand crafted from a heavy Lycra material. The shroud will provide protection against stray light, help guard against dew formation, and reduce the amount of dust that enters the telescope.

Install the shroud by sliding it over the sky-side end of the telescope.



Note: If you need to wash the shroud, please do so in a sink. The shroud material can bleed color when it is washed so it is advisable to wash the shroud by itself and only when absolutely necessary.

Warranty

AG Optical Systems warrants the products it manufactures against defects in materials and workmanship for a period of two years for the original purchaser of the item. AG Optical Systems at its sole discretion will determine if the product has defective materials and/or workmanship. The customer will be responsible for paying all shipping costs associated with the return of the item and must contact AG Optical Systems prior to returning the item. If AG Optical Systems determines the item to be defective in materials and/or workmanship, AG Optical Systems will reimburse the customer's shipping costs and pay for shipping to return the item to the customer.

The terms of this warranty are void if the product is used for a purpose for which it was not designed (to include solar observations) or is subject to abuse beyond normal use. Items not manufactured by AG Optical Systems are covered by the terms of the original manufacturer.